### Preoperative Prediction of Spinal Cord Ischemia in Complex Endovascular Aortic Aneurysm Repair

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**Objectives:** Endovascular repair has revolutionized the treatment of aortic aneurysms. Although the risks of endovascular aortic aneurysm repair (EVAR) are significantly less than those of open repair, the associated morbidity may still be high, as is the case with spinal cord ischemia. Identifying patients at the highest risk of spinal cord ischemia may allow for the application of more aggressive prophylactic techniques. We sought to establish a simple scoring system to predict the risk of spinal cord ischemia.

**Methods:** We retrospectively analyzed all patients who underwent complex EVAR at our institution. Patient and operative variables were compared using the Student *t*-test and $\chi^2$ tests. Significant variables on univariate analysis were entered into a stepwise logistic regression to establish a simple predictive model to estimate the risk of spinal cord ischemia.

**Results:** Of 109 patients who underwent complex EVAR, spinal cord ischemia developed in 12 (11%). The highest rate of spinal cord ischemia was documented in thoracoabdominal aneurysm repair. History of peripheral vascular disease, proportion of aortic coverage, number of aortic stent graft components, and total number of stent graft components were significantly associated with spinal cord ischemia. A weighted scoring system was devised using history of peripheral vascular disease and total number of stent graft components to stratify patients into low (<5%), medium (5%-10%), high (10%-20%), and very high (>20%) risk of spinal cord ischemia.

**Conclusions:** Patients undergoing complex EVAR can be stratified for the risk of spinal cord ischemia based on variables available preoperatively. Knowledge of a patient's individualized risk allows for a more personalized discussion of operative risks and benefits as well as identifying patients who stand to benefit the most from novel techniques designed to reduce the risk of spinal cord ischemia.

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### McGill University Sheath-Shunt Technique (MUSST) for Avoiding Lower Limb Ischemia During Complex Endovascular Aneurysm Repair

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**Objectives:** Complex aortic aneurysms are being repaired by endovascular techniques with increasing frequency. Although endovascular aortic aneurysm repair (EVAR) is generally associated with a reduction in complications compared with open repair, complex EVAR requires the use of a large-diameter introducer sheath that can occlude arterial flow to the lower limb. This fact, along with longer procedure times, suggests that complex EVAR techniques may increase the risk of lower limb ischemia and reperfusion injury.

**Methods:** We have adopted a technique whereby an additional 6F or 7F introducer sheath is placed distal to the stent graft introduction site in antegrade fashion. This sheath is then connected to the side arm of one of the introducer sheaths placed in the contralateral limb, allowing continuous perfusion of the limb distal to the stent graft introduction site. Arterial perfusion distal to the stent graft introduction site, before and during shunting, was assessed by duplex ultrasound imaging, and shunt flow was measured by transit-time flow measurement.

**Results:** In our initial experience with seven patients undergoing complex EVAR with confirmed occlusion of the native arterial system by the stent graft introduction site, occlusion time was 169 ± 55 minutes. Use of the sheath-shunt technique resulted in pulsatile flow in all patients, with an average flow of 45 ± 10 mL/min. There were no complications related to the use of this technique.

**Conclusions:** In patients undergoing complex EVAR who are at increased risk of lower limb ischemia and reperfusion injury, the McGill University Sheath-Shunt Technique (MUSST) results in continued perfusion of a limb that would otherwise be ischemic for a significant amount of time. Given the limited risk of this technique, coupled with the potential benefit, we propose its use in all patients undergoing complex EVAR.

**Author Disclosures: S. C. Hanley:** Use of custom-made thoracoabdominal branched graft made with paraplegia-prevention branches (not approved) and bridging limb using Atrium covered stents (off-label use). **S. K. Neequaye:** Nothing to disclose. **K. Mackenzie:** Nothing to disclose. **O. Steinmetz:** Use of custom made thoracoabdominal branched graft made with paraplegia-prevention branches (not approved) and bridging limb using Atrium covered stents (off-label use). **D. Obrand:** Use of custom made thoracoabdominal branched graft made with paraplegia-prevention branches (not approved) and bridging limb using Atrium covered stents (off-label use). **M. Corriveau:** Use of custom made thoracoabdominal branched graft made with paraplegia-prevention branches (not approved) and bridging limb using Atrium covered stents (off-label use). **C. Z. Abraham:** Use of custom made thoracoabdominal branched graft made with paraplegia-prevention branches (not approved) and bridging limb using Atrium covered stents (off label use); consulting fee, Cook Medical, Atrium Medical.

### Effects of Nonaxial Angulated Pullout Forces on Aortic Stent Graft Fixation

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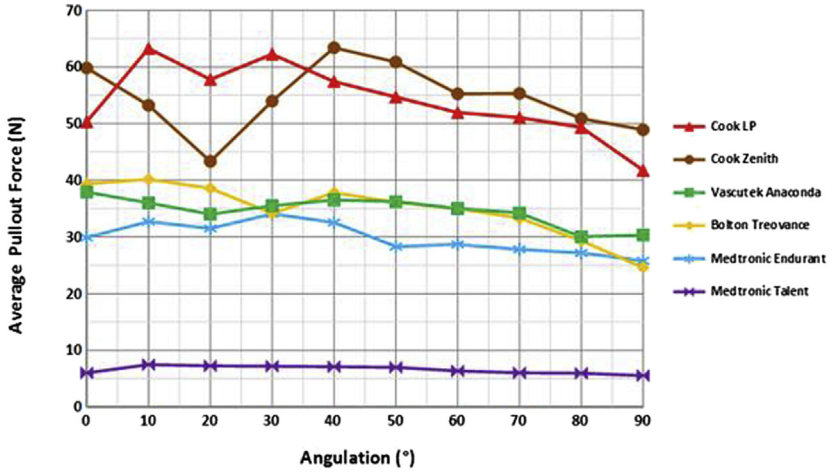


**Fig.** Plot of average pullout forces at different degrees of angulation for six different stent grafts.

**Objectives:** Experimentally measured pullout forces for stent grafts (SGs) are used in clinical discussions and as reference values in bench studies and computer simulation. However, available benchmarks in the literature have only been obtained straight along the axial direction, whereas studies suggest displacement forces are directed more anteriorly. We hypothesize that increasing angulation of the displacement force results in decreasing pullout force.

**Methods:** Sixty bifurcated SGs (10 new specimens for each of six devices: Bolton Treovance, Cook Zenith Flex, Cook Zenith LP, Medtronic Endurant, Medtronic Talent, and Vascutek Anaconda) were deployed in fresh bovine aortas and then pulled out using an electronic motor at 1 mm/s while tension force was measured continuously using a digital load cell. The SG off-axis angulation was changed from 0° to 90° in increments of 10°. The test system was submerged in a custom-built saline bath at 37°C. At least three tests were performed for each device at each angle, except for the Cook Zenith Flex, which experienced plastic deformation of its barbs. Each aortic specimen was used once and then discarded. Hand-sutured graft anastomoses were also tested at 0° for reference.

**Results:** Of 415 specimens of aorta that were tested, 67 tests were excluded due to failure of the aortic specimen or of the apparatus before device pullout. The remaining 348 pullouts are included in the Fig, which shows decreasing trends for the pullout forces for increasing angles for all six SGs. The mean pullout force for the handsewn anastomoses was 63 N (testing >70 N limited by apparatus failure).

**Conclusions:** This study supports the hypothesis that pullout forces generally decrease with increasing SG device angulation.

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### Is Endovascular Aneurysm Repair the New Gold Standard for Ruptured Abdominal Aortic Aneurysms?

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**Objectives:** This study compared outcomes of open aortic repair (OAR) vs endovascular aortic repair (EVAR) for ruptured abdominal aortic aneurysms (RAAA) in a single high-volume center.

**Methods:** An historical cohort analysis was conducted of all RAAAs treated at the Ottawa Hospital during the past 10 years with OAR or EVAR. Preoperative, intraoperative, and postoperative data points were obtained. Outcome measures included perioperative and long-term mortality, complications, and reintervention rates.

**Results:** A total of 264 consecutive patients (55 female; mean age, 73 ± 9 years) with RAAA underwent EVAR (n = 57) or OAR (n = 207) from 2003 to 2013. The overall 30-day mortality rate was 33%. Univariate analysis yielded a decreased 30-day mortality with EVAR compared with OAR (21.1% and 35.7%, respectively; $P = .02$). However, EVAR was not an independent predictor of improved survival after multivariate analysis. EVAR has been performed more frequently for RAAA in later years, with 75% of EVARs in this series performed during or after 2009, accounting for 36% of all RAAA repairs during this period. In contrast, OAR accounted for 81% of interventions between 2003 and 2008, inclusive. Mortality rates before and after 2009 remained comparable at 35.14% and 30.17%, respectively.

**Conclusions:** EVAR is being performed more frequently for RAAA repair due, in part, to observed perioperative mortality and morbidity benefits. However, the presumed advantage of this minimally invasive modality may reflect a selection bias, because this contemporary series and other ongoing trials have not detected any improvement in clinical outcomes with EVAR vs OAR when correcting for patient factors. Further research is required to identify a reproducible subset of patients in whom EVAR may indeed be superior to OAR as well as to assess the influence of training and technological advances on relative endovascular outcomes.

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### Long-Term Outcomes Following Repair of Ruptured Abdominal Aortic Aneurysms in Younger Patients

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**Objectives:** The purpose of this study was to determine the short-term and long-term outcomes and reintervention rates in patients aged ≤60 years who underwent repair of a ruptured abdominal aortic aneurysm.

**Methods:** A retrospective review of a prospectively collected vascular surgery database at a university affiliated medical center was conducted to identify all patients aged ≤60 years who underwent emergency repair between 2000 and 2013.

**Results:** Twenty seven patients (96.3% male) aged <60 years (mean age, 55.3 ± 11.2 years) underwent emergency repair (24 open, three EVAR). Most had a history of hypertension (68.2%) and current or past smoking (68.2%). The incidence of previous cardiac revascularization (9.1%) and chronic obstructive pulmonary disease (4.5%) was low in these young patients. The aneurysms were a mean maximum diameter of 7.5 ± 0.4 cm. The in-hospital 30-day mortality rate was 21.4%. The most common cause of in-hospital mortality was cardiac arrest (60%). There was one in-hospital reintervention requiring decompressive laparotomy for abdominal compartment syndrome. Mean hospital length of stay was 14 ± 12.1 days. Overall mean life expectancy was 8.9 years. Survival rates at 1 year, 5 years, and 10 years were 76%, 67%, and 61%, respectively. There were three reinterventions (16.7%) during a mean follow-up of 57.7 months. Two patients underwent incisional hernia repair, and one patient underwent further endovascular repair of an iliac artery aneurysm. There were no late aneurysm ruptures or aneurysm-related deaths during follow-up.

**Conclusions:** Younger patients after ruptured aneurysm repair have lower perioperative mortality rates than older patients. These younger patients have a reasonable 10-year survival rate with a low reintervention rate, which needs to be considered when deciding on method of repair.

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### Ruptured Abdominal Aortic Aneurysms in the Province of Quebec from 2006-2012: A Three-Steps Model for Centralization

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**Objectives:** Better survival for ruptured abdominal aortic aneurysm (RAAA) has been associated with the use of endovascular aneurysm repair (EVAR) compared with open surgical repair (OSR), high case volume, and young age. Is this also true in Quebec?

**Methods:** This was a retrospective review of data obtained from the Quebec hospital discharge database for RAAA repaired operatively between April 1, 2006, and March 31, 2012. OSR was compared with EVAR with two hospital volumes (low: <40 surgeries vs high: ≥40 surgeries). Logistic and log-binomial regression analyses identified the risk of 30-day mortality with age, hospital volume, and surgical groups as variables.

**Results:** For ages ≥65 years, 772 RAAA were found, with 725 OSR (93.9%) and 47 EVAR (6.1%). The rate of RAAA repair declined over the study period, from 11.57 to 9.66 per 100,000. The 30-day mortality was 36.6% for OSR compared with 19.2% for EVAR, ($P = .0157$). Low (39.5%) vs high (33.6%) hospital volume had similar 30-day mortality ($P = .108$). The relative risk was 1.94 ($P = .0289$) for OSR and was 1.54 ($P \leq .0001$) for patients aged ≥80 years. Hospital volume was not statistically significant.

**Conclusions:** Only the surgical group and age were significantly associated with 30-day mortality. EVAR was used only in 6% of the time for RAAA in Quebec; however, the relative risk of 30-day mortality was lower compared with OSR. Furthermore, hospitals with a low volume of OSR are not associated with a higher mortality. There is a trend towards a reduction of RAAA in Quebec.

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### Geographical Disparities in the Burden of Ruptured and Unruptured Abdominal Aortic Aneurysms in Saskatchewan

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